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Brief Communication

Intensity Threshold for 60-Hz Magnetically Induced Behavioral Changes in Rats

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Experiments were conducted to further investigate the effect of 60-Hz cyclotron-resonance exposures on rats performing on a multiple FR-DRL schedule. The previously reported temporary loss of DRL baseline response, when measured as a function of A.C. magnetic intensity, was found to have a threshold. Utilizing the component of A.C. magnetic intensity parallel to the D.C. field, we report this threshold as $(0.27 \pm 0.10) \times 10^{-4}$ T_{rms}.

Key words: cyclotron resonance, timing discrimination, A.C. threshold, DRL schedule

INTRODUCTION

We recently reported [Thomas et al., 1986] that rats operantly conditioned on a multiple, fixed ratio differential low-rate (FR-DRL) schedule exhibited a temporary loss of their DRL-baselines following a 30-min exposure to a specific combination of magnetostatic (0.261×10^{-4} T) and 60-Hz linearly polarized magnetic fields. The multiple schedule was such that when a red light was on the rat performed on an FR or counting schedule, pressing a lever 30 times (FR 30) to produce a food pellet. When a green light was illuminated a DRL schedule was in effect, with a pellet produced by a response on the lever following a preceding lever response by at least 18 s (DRL 18). Although performance on the FR schedule was not systematically affected by field exposure, there was a consistent modification in both the rate and pattern of responding on the DRL schedule following exposure to a combination of magnetic fields chosen to correspond to the cyclotron resonance tuning condition for

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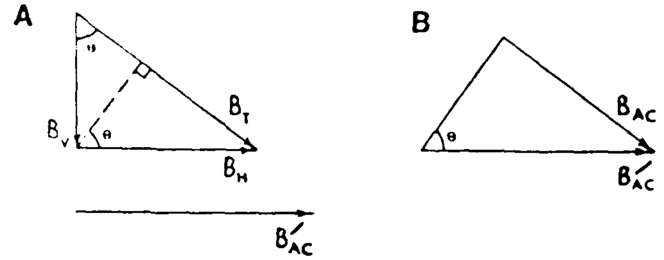

Fig. 1. Field configuration used by Thomas et al. [1986]. A: Magnetostatic components: $B_V = 0.157 \times 10^{-4}$ T, $B_H = 0.209 \times 10^{-4}$ T, $B_T = 0.261 \times 10^{-4}$ T. Direction $\mathbf{B_H}$ corresponds to compass heading (local geomagnetic north). In addition, 60-Hz linearly polarized magnetic field B'_{AC} applied parallel to B_H. B: Construction used to obtain $\mathbf{B_{AC}}$, the component of $\mathbf{B'_{AC}}$ in the direction of B_T. It follows that $B_{AC} = B'_{AC} \sin\theta = 0.801\ B'_{AC}$.

the singly charged lithium ion. The 60-Hz magnetic field exposure was directed horizontally within the N-S geomagnetic plane along the long axis of the rat. The minimum intensity of this field was 5×10^{-5} T_{rms}. The magnetostatic field was adjusted by partial compensation of the local geomagnetic field to a net intensity of 0.261×10^{-4} T at an angle of 36.8° to the horizontal (see Fig. 1).

It is important to point out that the cyclotron resonance condition that we applied in the original experiment does not depend on the intensity of the A.C. field. This condition is solely dependent on three variables: the frequency of the A.C. field, the magnetostatic intensity, and the ionic charge-to-mass ratio—in the present case, respectively, 60 Hz, 0.261×10^{-4} T, and 1.39×10^{7} Coul/kg. The role of the A.C. magnetic intensity in the interaction mechanism is not clear, except that it represents a potential means (albeit ultraweak) of energy transfer. The A.C. magnetic intensity also has practical significance since it is used as an exposure parameter in studying those biological effects resulting from power lines and other electromagnetic sources. It is therefore of some interest to determine how the effect reported by Thomas et al. [1986] varies with A.C. magnetic intensity under constant cyclotron resonance conditions.

Additional trials with the same animals were therefore conducted. Except for the range of A.C. magnetic intensities, these additional runs were carried out in precisely the same way as described in the initial report. The present results indicate that the loss of DRL baselines only occurs for 60-Hz intensities in excess of a clearly defined threshold.

The specific configuration of fields that were employed in both the initial and later experiments is shown in Figure 1. Note that $\mathbf{B_{AC}}$, the component of the 60-Hz field that is parallel to the total magnetic field vector ($\mathbf{B_T}$), is only 80% of the actual applied field, B'_{AC}. The values of field that were selected for the initial experiment were chosen by using the fact that 0.261×10^{-4} T is close to cyclotron resonance for lithium ions at 60 Hz. Therefore, in examining the dependence of behavioral response upon A.C. magnetic intensity, we restrict our consideration to that component of the A.C. signal (i.e., $\mathbf{B_{AC}}$) that is in cyclotron resonance with the magnetostatic field $\mathbf{B_T}$.

In Figure 2 the relative (compared to sham) response rate, averaged over the five individual mean response rates following 30-min exposures to 0.261×10^{-4} T, 60 Hz, is plotted as a function of the rms intensity of the A.C. field. The solid curve

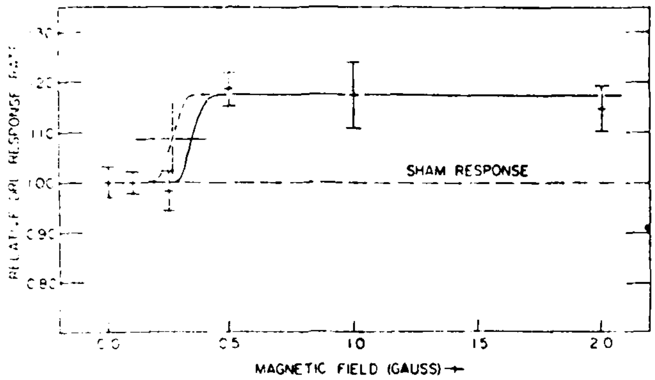

Fig. 2. Variation in the relative response rate as a function of rms intensity of 60-Hz magnetic field. Each of the six points shown represents the mean value averaged over the same five rats used in Thomas et al. [1986]. The coordinates of these points correspond to the applied field intensity B'_{AC}. The dashed curve indicates how this curve is shifted toward lower values when determining the response as a function of B_{AC}. By assuming that the mean level for this transition occurs halfway between the sham response level and the higher response plateau, we estimate the threshold intensity for this transition at $0.27 \times 10^{-4}\ T_{rms}$.

represents the variation with B'_{AC} and the dashed curve represents this variation as a function of B_{AC}. We estimate that the mean threshold for loss of DRL response rate is $B_{AC} = 0.27 \times 10^{-4}\ T_{rms}$. Since the uncertainty in this value is dominated by the separation of the two points (0.2×10^{-4} T) just below and just above the transition region, we report the threshold intensity for the behavioral effect previously reported as $(0.27 \pm 0.10) \times 10^{-4}\ T_{rms}$.

This study was part of a research program to determine the possible adverse health effects resulting from exposure to the electric and magnetic fields of overhead high-voltage transmission lines, administered by the State of New York Department of Health and Health Research, Inc. The study was also supported by the U.S. Naval Medical Research and Development Command Work Unit No. MF58.524.02C.0001.

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